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Nanostructured Nb-doped TiO₂ thin films and colloidal suspensions: a Nb K-edge EXAFS study

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Introduction: Nanostructured TiO₂ and dye-sensitized Nanostructured TiO₂ are important electrode materials in photocatalytic and photovoltaics applications. However, better fundamental knowledge is required to optimize the efficiency of such devices. For instance, in order to elucidate the effect of dopant on the electron transport in nanostructured metal oxides and in particular in TiO₂, the most common electrode for photoelectrochemical devices, we have designed a synthesis that enables us to produce Nb-doped TiO₂ anatase thin films and suspensions containing up to 35 mol% of niobium.

Methods and Materials: The synthesis is based on a solution chemical route using alkoxide precursors (i.e. Ti(OPr)ⁱ₄ and Nb(OEt)₅) in organic solvent, hydrolysed under vigorous stirring in basic solution. The precipitate is then heat-treated to obtain the crystalline phase of anatase with firmly agglomerated nano-powder¹. Suspensions of nanoparticles with various content of niobium are obtained by hydrothermal process and nanostructured thin films of about 10 μm in thickness are obtained by coating conducting glass substrates with the concentrated suspensions (nanoparticles of 25 to 80 nm in diameter depending on the niobium content) and subsequent heat treatment at 450C in air.

Results: The Nb K-edge XANES/EXAFS of the suspensions and thin films samples clearly shows that the niobium atoms are in their highest formal oxidation state (+V) and significant changes in the local coordination is observed as the Nb content is increasing. Figure 1 shows the Nb K-edge spectra recorded in fluorescence mode on Nb-doped anatase TiO₂ thin films samples containing various amount of Nb.

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References: [1] M. Leideborg et al. Proceedings of the 9th Cimtec-World Ceramics Congress B 143-150 (1999).

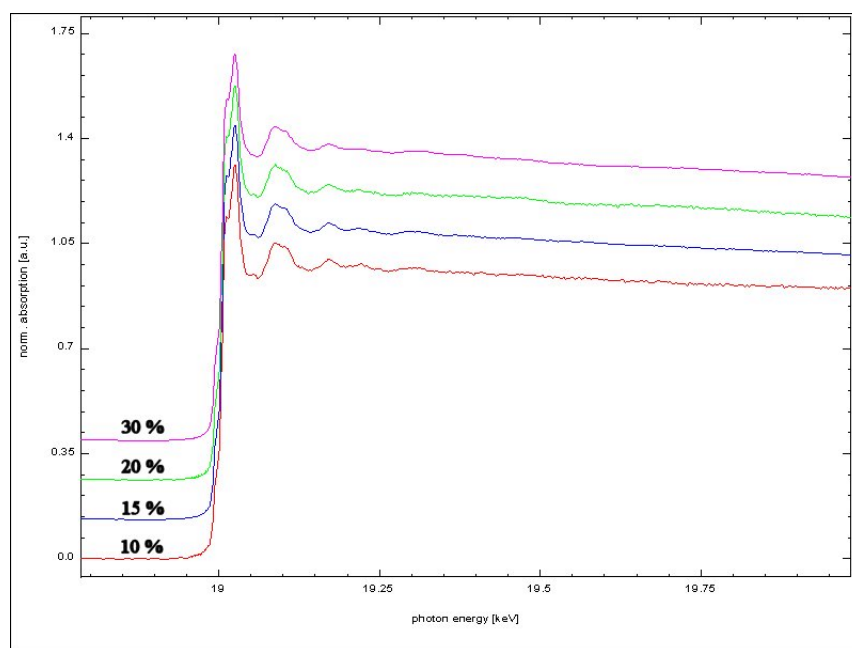


Figure 1. Nb K-edge EXAFS spectra of nanostructured Nb-doped anatase TiO₂ thin films of various mol% of Nb.